Joint Transportation Research Program

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Synthesis Study: Repair and Durability of Fire-Damaged Prestressed Concrete Bridge Girders

Introduction

This project focused on investigating current knowledge of assessments and repair/retrofit methods for prestressed concrete bridge girders subjected to fire. A synthesis study was conducted to gather and organize research-based, practical information, which included reviewing existing documents and a survey of practice. Knowledge obtained from the detailed literature review and survey study was analyzed and synthesized to find insight into plausible treatments for fire-damaged bridges. The primary topics of this study were (1) repair/retrofit methods for prestressed concrete bridge girders, (2) assessing the structural performance (serviceability and strength) of repaired girders, and (3) assessing the durability of damaged, unrepaired, and repaired prestressed girders. Through this study, bridge inspectors and engineers have a proper reference to develop a rational post-fire assessment/repair plan for the concrete bridge girders with various levels of fire damage.

Findings

- Several case studies about the prestressed concrete bridges that experienced serious fire incidents were reviewed. These studies reported the distribution and severity of fire-induced damage for the target bridges. Moreover, different potential repair strategies were also investigated and implemented to restore the damaged bridges. These studies suggest that the concrete bridge girders mostly have superficial concrete damage after severe fire scenarios (e.g., five hours burning, which raised the concrete surface temperature to 1,112°F (600°C)). On the contrary, the degradation of the steel strands' mechanical properties and prestressing force may be localized and insignificant, which agrees well with the findings observed in the INDOT research project SPR-4221.
- Next, the research team reviewed the documents and standard specifications about the damage level classification and repair methods of fire-damaged concrete bridges. Features and limitations of different retrofit strategies are discussed and presented, which include (3) concrete surface repair, (2) patch concrete, (3) pressure-injection of Epoxy resins, (4) concrete removal/cast-in-place concrete, (5) tendon cleaning/coating, (6) steel encasement, (7) Fiber Reinforced Polymer (FRP) Wrapping, and (8) replacing the damaged structure. After comparison, the Carbon Fiber Reinforced Polymer (CFRP)-based repair techniques is generally more advantageous than other alternatives for restoring fire-damaged concrete bridges. However, the fire resistance of FRP-based repair may be a concern since the typically adopted epoxy adhesive system is fragile at high temperatures (with a suggested maximum service temperature range of 140°F to 180°F (60°C to 82°C)). Therefore, in fire-critical cases, fireproofing systems may be necessary.
- A survey form (online and paper-based version) was prepared by the research team and distributed to nineteen representatives from state DOTs and the AASHTO Subcommittee on Bridges and Structures (COBS). The questionnaire was developed to collect the current practices

regarding the post-fire assessment and typically adopted repair/retrofit methods for prestressed concrete bridge girders that sustain different fire damage levels. In general, not many cases of fire-damaged concrete bridges can be studied. And the damage level of available cases is mainly minor (concrete cracks and shallow spalls which do not affect tendons) or moderate (large concrete cracks and spalls; exposed, undamaged tendons). This finding agrees with the observations from the reviewed case studies and the previous INODT research project.

- Based on the survey results, most respondents (74%) will choose not to repair the damaged bridges for concrete bridges with minor fire damage. On the other hand, bridges with moderate fire damage are usually repaired using various methods. These repair methods are similar to retrofit approaches reviewed in the published documents (e.g., patch concrete, concrete replacement, and steel/FRP jacketing). In addition, most survey respondents claimed that there is no major issue with the durability and serviceability of the repaired bridge if the repair is performed successfully. Nevertheless, due to the limited cases and lack of existing studies on unrepaired or repaired fire-damaged concrete girders, their long-term performance and durability may be questionable. Therefore, additional research is needed to address these concerns. Lastly, most agencies prefer to replace the entire damaged structure when a concrete girder bridge undergoes significant fire damage (exposed and damaged tendons; loss of a portion of cross-section), although it rarely happens.

Implementation

Through this study, bridge inspectors and engineers have a reference for developing a proper plan to restore a fire-damaged bridge to its expected strength and serviceability after evaluating the safety and efficiency issues of different probable schemes.

However, although this report includes various approaches in dealing with fire-damaged concrete bridges, the representative should still make their final decision after considering all the conditions and limitations (e.g., economy and constructability issues) of the actual scenario.

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